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(71) Applicant: VIROGENETICS CORPORATION [US/US]; 465 Jordan Road, Rensselaer Technology Park, Troy, NY 12180 (US).

(72) Inventors: PAOLETTI, Enzo ; 297 Murray Avenue, Delmar, NY 12054 (US). TAYLOR, Jill ; 33 Colonial Avenue, Albany, NY 12203 (US). GETTIG, Russell ; R.D. 2, Box 421C, Averill Park, NY 12018 (US).

(74) Agents: FROMMER, William, S. et al.; Curtis, Morris & Safford, 530 Fifth Avenue, New York, NY 10036 (US).

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(54) Title: INFECTIOUS BURSAL DISEASE VIRUS RECOMBINANT POXVIRUS VACCINE

(57) Abstract

What is described is a recombinant poxvirus, such as fowlpox virus, containing foreign DNA from infectious bursal disease virus. What is also described is a vaccine containing the recombinant poxvirus for inducing an immunological response in a host animal inoculated with the vaccine.

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INFECTIOUS BURSAL DISEASE VIRUS RECOMBINANT POXVIRUS VACCINE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of copending application Serial No. 07/736,254 filed July 26, 1991, incorporated herein by reference. Reference is also made to copending application Serial No. 07/847,951, filed March 6, 1992, also incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to a modified poxvirus and to methods of making and using the same. More in particular, the invention relates to recombinant poxvirus, which virus expresses gene products of an infectious bursal disease virus (IBDV) gene, and to vaccines which provide protective immunity against IBDV infections.

Several publications are referenced in this application. Full citation to these documents is found at the end of the specification preceding the claims. These documents pertain to the field of this invention; and, each of the documents referenced in this application are hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

Vaccinia virus and more recently other poxviruses have been used for the insertion and expression of foreign genes. The basic technique of inserting foreign genes into live infectious poxvirus involves recombination between pox DNA sequences flanking a foreign genetic element in a donor plasmid and homologous sequences present in the rescuing poxvirus (Piccini et al., 1987).

Specifically, the recombinant poxviruses are constructed in two steps known in the art and analogous to the methods for creating synthetic recombinants of the vaccinia virus described in U.S. Patent Nos. 5,110,587, 4,769,330, 4,722,848, and 4,603,112; the disclosures of

each of these patents is incorporated herein by reference. Reference is also made to copending application Serial No. 07/537,890, filed June 14, 1990, also incorporated herein by reference.

First, the DNA gene sequence to be inserted into the virus, particularly an open reading frame from a non-pox source, is placed into an *E. coli* plasmid construct into which DNA homologous to a section of DNA of the poxvirus has been inserted. Separately, the DNA gene sequence to be inserted is ligated to a promoter. The promoter-gene linkage is positioned in the plasmid construct so that the promoter-gene linkage is flanked on both ends by DNA homologous to a DNA sequence flanking a region of pox DNA containing a nonessential locus. The resulting plasmid construct is then amplified by growth within *E. coli* bacteria (Clewell, 1972) and isolated (Clewell et al., 1969; Sambrook et al., 1989).

Second, the isolated plasmid containing the DNA gene sequence to be inserted is transfected into a cell culture, e.g. chick embryo fibroblasts, along with the poxvirus. Recombination between homologous pox DNA in the plasmid and the viral genome respectively gives a poxvirus modified by the presence, in a nonessential region of its genome, of foreign DNA sequences. The term "foreign" DNA designates exogenous DNA, particularly DNA from a non-pox source, that codes for gene products not ordinarily produced by the genome into which the exogenous DNA is placed.

Genetic recombination is in general the exchange of homologous sections of DNA between two strands of DNA. In certain viruses RNA may replace DNA. Homologous sections of nucleic acid are sections of nucleic acid (DNA or RNA) which have the same sequence of nucleotide bases.

Genetic recombination may take place naturally during the replication or manufacture of new viral genomes within the infected host cell. Thus, genetic

recombination between viral genes may occur during the viral replication cycle that takes place in a host cell which is co-infected with two or more different viruses or other genetic constructs. A section of DNA from a first genome is used interchangeably in constructing the section of the genome of a second co-infecting virus in which the DNA is homologous with that of the first viral genome.

However, recombination can also take place between sections of DNA in different genomes that are not perfectly homologous. If one such section is from a first genome homologous with a section of another genome except for the presence within the first section of, for example, a genetic marker or a gene coding for an antigenic determinant inserted into a portion of the homologous DNA, recombination can still take place and the products of that recombination are then detectable by the presence of that genetic marker or gene in the recombinant viral genome.

Successful expression of the inserted DNA genetic sequence by the modified infectious virus requires two conditions. First, the insertion must be into a nonessential region of the virus in order that the modified virus remain viable. The second condition for expression of inserted DNA is the presence of a promoter in the proper relationship to the inserted DNA. The promoter must be placed so that it is located upstream from the DNA sequence to be expressed.

The technology of generating vaccinia virus recombinants has recently been extended to other members of the poxvirus family which have a more restricted host range. The avipox virus, fowlpox, has been engineered as a recombinant virus. This recombinant virus is described in PCT Publication No. WO89/03429, also incorporated herein by reference.

Fowlpox virus (FPV) has advantageously been engineered as a vector expressing antigens from poultry

pathogens. The hemagglutinin protein of a virulent avian influenza virus was expressed in an FPV recombinant (Taylor et al., 1988). After inoculation of the recombinant into chickens and turkeys, an immune response was induced which was protective against either a homologous or heterologous virulent influenza virus challenge (Taylor et al., 1988). In addition, the surface glycoproteins (fusion and hemagglutinin) of a virulent strain of Newcastle Disease Virus have been expressed in an FPV vector and shown to induce a protective immune response (Taylor et al., 1990; Edbauer et al., 1990).

FPV is the prototypic virus of the Avipox genus of the Poxvirus family. The virus causes an economically important disease of poultry which has been well controlled since the 1920's by the use of live attenuated vaccines. Replication of the avipox viruses is limited to avian species (Matthews, 1982) and there are no reports in the literature of the virus causing a productive infection in any non-avian species including man. This host restriction provides an inherent safety barrier to transmission of the virus to other species and makes use of FPV as a vaccine vector in poultry an attractive proposition.

Infectious bursal disease, also known as Gumboro's disease, manifests itself in two ways. In chickens older than three weeks, infectious bursal disease virus (IBDV) can cause impaired growth and mortality losses of up to 20% (Lukert and Hitchner, 1984). In younger birds, the disease is subclinical but is evident as microscopic lesions in the bursa of Fabricius (Winterfield et al., 1972). This results in prolonged and severe immunosuppression which causes increased susceptibility to disease and interferes with vaccination programs against other disease agents (Allan et al., 1972). Characteristics of the disease have been

reviewed in Lukert and Saif (1991) and will be summarized briefly here.

The cloacal bursa appears to be the primary target organ of the virus and birds surgically bursectomized at 4 weeks have been shown to survive a lethal IBDV challenge without clinical manifestations (Kaufer and Weis, 1980). The age of bursectomy is however, critical. Schat et al., (1981) performed embryonal bursectomy and then challenged with IBDV at 2 and 6 weeks of age. Birds developed typical hemorrhagic lesions, were clinically ill and showed some mortality. The target cells are actively dividing B lymphocytes (Muller, 1986; Burkhardt and Muller, 1987). Muller (1986) demonstrated that IBDV will replicate preferentially in lymphoid cells from the bursa and poorly in lymphoid cells from other organs. It has been proposed that clinical signs of IBDV infection may result from immune complex formation (Ley et al., 1979; Skeeles et al., 1979). Muller (1986) however, demonstrated that the preferential replication in the lymphoid cells of the bursa is not related to the presence of surface immunoglobulins.

Two serotypes of IBDV, designated 1 and 2 have been demonstrated (McFerran et al., 1980; Jackwood et al., 1984; McNulty and Saif, 1988). Virulent serotypes have been shown in Group 1. No disease has been associated with group 2 viruses. In addition, considerable antigenic variation has been documented within serotypes (Lukert and Saif, 1991).

The causative agent, IBDV, has been classified as a Birnavirus (Brown et al., 1986). The biochemistry and replication of IBDV has been reviewed in Kibenge et al., (1988). Birnaviruses are small non-enveloped animal viruses having two segments of double-stranded RNA. The smaller genomic segment (segment B) of IBDV encodes a single polypeptide of 90k designated VP1. This protein is a minor internal component of the virion and is

presumed to be the viral RNA polymerase (Hudson et al., 1986; Nagy et al., 1987; Spies et al., 1987). The larger genomic segment (segment A) encodes 5 polypeptides with the following designations and approximate molecular weights 52k (VPX), 41k (VP2), 32k (VP3), 28k (VP4) and 16k (Azad et al., 1985). The identity and presence of the 16K polypeptide has not been confirmed (Kibenge et al., 1988). VP2, VP3 and VP4 arise by co-translational proteolytic cleavage of precursor polyproteins. The protein VP4 is thought to be a viral protease (Hudson et al., 1986) responsible for cleavage between VPX and VP4 (Duncan et al., 1987) and between VP4 and VP3 (Azad et al., 1987; Jagadish et al., 1988).

Protein VP2 is the most abundant protein of the viral capsid making up 51% of serotype I IBDV proteins (Dobos et al., 1979). VP2 is only found in mature viral particles and is not seen in IBDV infected cells (Becht et al., 1988). VP2 is thought to be a specific cleavage product of a VPX precursor. Peptide mapping has shown that VPX and VP2 of IBDV strain CU-1 have similar amino acid sequences (Muller and Becht, 1982; Dobos, 1979). In addition both VPX and VP2 react with the same monoclonal antibody on Western blots (Fahey et al., 1985b; Becht et al., 1988). It has recently been demonstrated that a conformational dependent neutralizing epitope exists on VP2 (Azad et al., 1987; Fahey et al., 1989) and a conformation independent neutralizing epitope exists on VP3 (Fahey et al., 1985 a,b). Antibodies to these epitopes were found to passively protect chickens (Fahey et al., 1985b; Azad et al., 1987; Fahey et al. 1989). Becht et al., (1988) and Snyder et al., (1988) indicated that neutralizing monoclonal antibodies to VP2 differentiated between serotypes 1 and 2 in cross-neutralization tests. However, Becht et al., (1988) also indicated that monoclonal antibodies to VP3 recognized a group-specific antigen from both serotypes which was not associated with neutralizing activity or protection.

These studies may indicate the existence of multiple epitopes at least on VP2 and perhaps on VP3.

In a recent publication, Macreadie et al., (1990) demonstrated the expression of VP2 in a yeast vector. The size of the expressed protein was consistent with that of an authentic VP2. Centrifugation and gel filtration studies indicated that the VP2 expressed in yeast was in a high molecular weight aggregated form. Chickens inoculated with a crude extract of the yeast expressed VP2 developed an immune response as demonstrated by ELISA test and virus neutralization tests. One day old chickens were then inoculated with anti-sera from chickens previously inoculated with yeast expressed VP2. These chickens were passively protected against IBDV challenge as evidenced by lack of IBDV antigen in the bursa (Macreadie et al., 1990).

Current vaccination strategies against IBDV include both live and killed vaccines. Antibody transmitted from the hen via the yolk of the egg can protect chickens against early infections with IBDV. Therefore, use of killed vaccines in oil emulsions to stimulate high levels of maternal antibody is extensive in the field (Lukert and Saif, 1991). Studies by Lucio and Hitchner (1979) and Baxendale and Lutticken (1981) indicated that oil emulsion IBDV vaccines can stimulate adequate maternal immunity to protect chickens for 4-6 weeks. In contrast progeny from breeders vaccinated with live vaccines are protected for only 1-3 weeks after hatching (Lukert and Saif, 1991).

Determination of when maternal antibody has waned, and thus when antibody levels can be boosted by active immunization is problematical. It is therefore common practice to vaccinate all chicks against IBD with a live vaccine during the first 3 weeks of life (Winterfield et al., 1980). Inactivated vaccines are ineffective in inducing active immunity in chicks with maternal antibody. Presently available live vaccines

consist of strains of intermediate virulence or highly attenuated strains, as well as some cell culture adapted variant strains. While intermediate strains can break through maternal antibody titers of approximately 1:250 (Lukert and Saif, 1991), the strains vary in virulence and can induce bursal atrophy and immunosuppression in day old and 3 week old SPF chickens (Lukert and Mazariegos, 1985).

Given the limitations of current vaccination strategies, it can be appreciated that provision of an IBDV recombinant poxvirus, and of vaccines which provide protective immunity against IBDV infections, would be a highly desirable advance over the current state of technology.

OBJECTS OF THE INVENTION

It is therefore an object of this invention to provide recombinant poxviruses, which viruses express gene products of IBDV, and to provide a method of making such recombinant poxviruses.

It is an additional object of this invention to provide for the cloning and expression of IBDV coding sequences, particularly sequences coding for IBDV structural proteins, in a poxvirus vector, particularly fowlpox virus.

It is another object of this invention to provide a vaccine which is capable of eliciting IBDV antibodies and protective immunity against IBDV infection.

These and other objects and advantages of the present invention will become more readily apparent after consideration of the following.

STATEMENT OF THE INVENTION

In one aspect, the present invention relates to a recombinant poxvirus containing therein a DNA sequence from IBDV in a nonessential region of the poxvirus genome. The poxvirus is advantageously an avipox virus, such as fowlpox virus.

According to the present invention, the recombinant poxvirus expresses gene products of the foreign IBDV gene. In particular, the foreign DNA codes for IBDV structural proteins. The IBDV gene may be co-expressed with other foreign genes in the host by the recombinant poxvirus.

In another aspect, the present invention relates to a vaccine for inducing an immunological response in a host animal inoculated with the vaccine, said vaccine including a carrier and a recombinant poxvirus containing, in a nonessential region thereof, DNA from IBDV. Advantageously, the DNA codes for and expresses IBDV structural proteins. The IBDV gene may be co-expressed with other foreign genes in the host. The poxvirus used in the vaccine according to the present invention is advantageously an avipox virus, such as fowlpox virus, referred to hereafter as TROVAC.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention will be had by referring to the accompanying drawings, in which:

FIG. 1 (SEQ ID NO:7) shows the nucleotide sequence of a 3661 base pair fragment of TROVAC DNA containing the F8 open reading frame; and

FIG. 2 (SEQ ID NO:12) shows the nucleotide sequence of a 3659 base pair fragment of TROVAC DNA containing the F8 open reading frame.

DETAILED DESCRIPTION OF THE INVENTION

The invention is directed to recombinant poxviruses containing therein a DNA sequence from IBDV in a nonessential region of the poxvirus genome. The recombinant poxviruses express gene products of the foreign IBDV gene. In particular, IBDV genes encoding IBDV structural proteins were isolated, characterized and inserted into TROVAC (FPV) recombinants.

Cell Lines and Virus Strains. The strain of FPV designated FP-1 has been previously described (Taylor

et al., 1988). It is an attenuated vaccine strain useful in vaccination of day old chickens. The parental virus strain Duvette was obtained in France as a fowlpox scab from a chicken. The virus was attenuated by approximately 50 serial passages in chicken embryonated eggs followed by 25 passages on chicken embryo fibroblast (CEF) cells. This virus was obtained in September 1980 by Rhone Merieux, Lyon, France and a master viral seed established. Subsequently, the virus was subjected to four successive plaque purifications. One plaque isolate was further amplified in primary CEF cells, and a stock virus, designated as TROVAC, established.

cDNA clones from IBDV strain Faragher (Type I) were obtained from Rhone Merieux, Lyon, France.

Example 1 - CONSTRUCTION OF INSERTION VECTOR FOR IBDV-VP2

Plasmid pIBDVA contains a 3.1 Kb KpnI to XbaI fragment derived from cDNA clones of IBDV strain Faragher. This fragment was inserted into vector pBluescript II SK+ (Stratagene, La Jolla, CA). The insert corresponds to the segment A of the IBDV genome which encodes the 108 kDa precursor polyprotein. The polyprotein is subsequently processed to form VP2, VP3 and VP4.

In order to isolate the coding sequence for VP2 from pIBDVA, VP3 and VP4 coding sequences were deleted from pIBDVA and a termination codon added to the 3′ end of the VP2 coding sequence. This was accomplished by digestion of pIBDVA with ScaI and KpnI and insertion of the annealed and kinased oligonucleotides CE279 (SEQ ID NO:1) and CE280 (SEQ ID NO:2) to form pCEN112.

CE279

ACTTCATGGAGGTGGCCGACCTCAACTCTCCCCTGAAGATTGCAGGAGCATT
TGGCTTCAAAGACATAATCCGGGCTATAAGGAGGTGAGTCGACGGTAC

CE280

CGTCGACTCACCTCCTTATAGCCCGGATTATGTCTTTGAAGCCAAATGCTCC
TGCAATCTTCAGGGGAGAGTTGAGGTCGGCCACCTCCATGAAGT

The vaccinia virus H6 promoter previously described in Taylor et al., (1988); Guo et al., (1989), Perkus et al., (1989), was inserted into pCEN112 by digesting pCEN112 with NotI, and blunt-ending with the Klenow fragment of DNA polymerase, in the presence of 10 mM dNTPs. A HindIII to EcoRV fragment which contains the H6 promoter was blunt-ended with the Klenow fragment of DNA polymerase and inserted into the linearized pCEN112 to generate pCEN117.

In order to couple the promoter sequence with the initiating ATG of IBDV VP2 coding sequence, the annealed and kinased oligonucleotides CE277 (SEQ ID NO:3) and CE278 (SEQ ID NO:4) were inserted into pCEN117 that had been digested with NruI and RsrII. The resulting plasmid was designated pCEN120.

CE277

CGATATCATGACAAACCTGCAAGATCAAACCCAACAGATTGTTCCGTTCATA
CGGAGCCTTCTGATGCCAACAACCG

CE278

GTCCGGTTGTTGGCATCAGAAGGCTCCGTATGAACGGAACAATCTGTTGGGT
TTGATCTTGCAGGTTTGTCATGATATCG

A SmaI to SalI fragment from pCEN120, containing IBDV-VP2 linked to the vaccinia virus H6 promoter was cloned into the HpaI and SalI sites of the FPV insertion vector pCEN100 (described below) to generate pCEN137. Plasmid pCEN137 was used in an *in vitro* recombination test to generate recombinant vFP115.

Example 2 - CONSTRUCTION OF INSERTION VECTOR FOR IBDV VP2, VP3, VP4

Non-coding sequence was removed from the 3' end of the IBDV polyprotein sequence by partially digesting pIBDVA with PpuMI, completely digesting with KpnI, and re-inserting the annealed and kinased oligonucleotides CE275 (SEQ ID NO:5) and CE276 (SEQ ID NO:6) into pIBDVA to generate pCEN111.

CE275: GACCTTGAGTGAGTCGACGGTAC

CE276: CGTCGACTCACTCAAG

A perfect 5′ end to the polyprotein sequence was obtained in the following manner. A KpnI-BstEII fragment containing the majority of the polyprotein sequence with a perfect 3′ end was excised from pCEN111 and ligated into the KpnI and BstEII sites of pCEN120. This substitution replaces the 3′ end of the VP2 coding sequence and generates a perfect 5′ end for the polyprotein with linkage to the vaccinia virus H6 promoter. The resulting plasmid was designated pCEN125. The final insertion plasmid was constructed by partial digestion of pCEN125 with SmaI and complete digestion with SalI. The resulting fragment was cloned into the HpaI and SalI sites of pCEN100 (described below) to form pCEN138. Plasmid pCEN138 was used in an *in vitro* recombination test to generate recombinant vFP116.

Example 3 - CONSTRUCTION OF FOWLPOX INSERTION PLASMID AT F8 LOCUS

Plasmid pRW731.15 contains a 10 Kbp PvuII-PvuII fragment cloned from TROVAC genomic DNA. The nucleotide sequence was determined on both strands for a 3661 bp PvuII-EcoRV fragment. This sequence is shown in Figure 1 (SEQ ID NO:7). The limits of an open reading frame designated in this laboratory as F8 were determined within this sequence.

Subsequently, the nucleotide sequence of Fig. 1 was further analyzed and was determined on both strands to be a 3659 bp PvuII-EcoRV fragment. This sequence is shown in Figure 2 (SEQ ID NO:12). The limits of the open reading frame designated in this laboratory as F8 were determined within this sequence; and, the subsequent determination of the sequence, as shown in Fig. 2, does not affect the reproducibility of this or any other construction involving the fowlpox F8 locus determined by this laboratory, especially because the deletions and insertions into the F8 ORF can be performed by the skilled artisan following the teachings from this laboratory, such as the following description, without

recourse to the sequence of the F8 ORF or the PvuII-EcoRV fragment within which it is contained. Based on sequence information contained in Figure 2, the open reading frame is initiated at position 495 and terminates at position 1887. A deletion was engineered from what was ultimately determined to be position 779 to position 1926, as described below.

Plasmid pRW761 is a sub-clone of pRW731.15 containing a 2430 bp EcoRV-EcoRV fragment. Plasmid pRW761 was completely digested with XbaI and partially digested with SspI. A 3700 bp XbaI-SspI band was isolated and ligated with the annealed double-stranded oligonucleotides JCA017 (SEQ ID NO:8) and JCA018 (SEQ ID NO:9).

JCA017 5′ CTAGACACTTTATGTTTTTTAATATCCGGTCTTAAAAGCTTCCCGGG
GGATCCTTATACGGGGAATAAT 3′

JCA018 5′ ATTATTCCCCGTATAAGGATCCCCCGGGAAGCTTTTAAGACCGGATA
TTAAAAAACATAAAGTGT 3′

The plasmid resulting from this ligation was designated pJCA002.

Additional cloning sites were incorporated into pJCA002 by inserting the annealed and kinased oligonucleotides CE205 (SEQ ID NO:10) and CE206 (SEQ ID NO:11) into the BamHI and HindIII sites of pJCA002 to form pCE72.

CE205: GATCAGAAAAACTAGCTAGCTAGTACGTAGTTAACGTCGACCTGCAG
AAGCTTCTAGCTAGCTAGTTTTTAT

CE206: AGCTATAAAAACTAGCTAGCTAGAAGCTTCTGCAGGTCGACGTTAAC
TACGTACTAGCTAGCTAGTTTTTCT

In order to increase the length of the FPV flanking arms in the insertion plasmid, plasmid pJCA021 was constructed. Plasmid pJCA021 was obtained by inserting a 4900bp PvuII-HindII fragment from pRW731.15 (described above) into the SmaI and HindII sites of pBluescript SK+ (Stratagene, La Jolla, CA). A BglII to EcoRI fragment from pCEN72 was then ligated into the BglII and EcoRI sites of pJCA021 to generate pCEN100.

Example 4 - DEVELOPMENT OF TROVAC-IBDV RECOMBINANTS

Plasmids pCEN137 and pCEN138 were transfected into TROVAC infected primary CEF cells by using the calcium phosphate precipitation method previously described (Panicali and Paoletti, 1982; Piccini et al., 1987). Positive plaques were selected on the basis of hybridization to specific IBDV radiolabeled probes and subjected to five sequential rounds of plaque purification until a pure population was achieved. One representative plaque from each IVR was then amplified and the resulting TROVAC recombinants were designated vFP115 (IBDV-VP2) and vFP116 (IBDV-VP2, VP3, VP4).

Immunofluorescence. In order to determine where the IBDV proteins were localized in recombinant infected CEF cells, immunofluorescence analysis was performed. Indirect immunofluorescence was performed was performed as described in Taylor et al., (1990) using a neutralizing monoclonal antibody preparation specific for VP2 and designated AC6 and and a VP3 specific monoclonal antibody designated NA3 obtained from Rhone Merieux. In addition, a polyclonal chicken anti-IBDV serum was obtained from Spafas Inc., Storrs, CT.

The results indicated that IBDV specific immunofluorescence could be detected in the cytoplasm of cells infected with either vFP115 or vFP116. No fluorescence was detected in parental TROVAC infected CEF cells. No surface fluorescence was detected in cells infected with either recombinant virus. Equivalent results were obtained using both the neutralizing monoclonal antibody preparation and the polyclonal immune serum. The result was not unexpected since the analysis of the sequence of the IBDV genes does not indicate the presence of characteristic signal and anchor sequences which would direct insertion of the proteins in the infected cell membrane.

Immunoprecipitation. Immunoprecipitation reactions were performed as described in Taylor et al.,

(1990) using the monoclonal antibody preparations and the polyclonal anti-IBDV immune serum from chickens as described above.

Immunoprecipitation analysis of CEF cells infected with recombinant vFP115 indicated the expression of a protein of approximately 38-40 Kd recognized by both polyclonal immune sera and the neutralizing monoclonal antibody. This size is appropriate for expression of the structural protein, VP2 (Azad et al., 1985). Immunoprecipitation analysis of lysates of cells infected with recombinant vFP116 encoding the IBDV polyprotein, with the same serological reagents, also demonstrated expression of a single protein species of approximately 43 kd. This protein is recognized by both polyclonal immune serum and the neutralizing monoclonal antibody preparation. Both the size of the protein and its recognition by the monoclonal antibody indicate that the identity of this protein may be VPX, the precursor to VP2. Although no other proteins are immunoprecipitated by the polyclonal immune serum, presence of the cleaved VPX indicates that VP4, the cleavage protein is probably expressed. Since VP4 is a very minor component of the virion, it is not unusual that the immune serum should not contain antibodies to this protein. Use of the VP3 specific monoclonal antibody indicated the expression of a protein of 32 kd in cells infected with vFP116.

Example 5 - IMMUNIZATION OF CHICKENS AND SUBSEQUENT CHALLENGE

Groups of 20, 5 day old susceptible SPF chickens were inoculated by subcutaneous injection in the nape of the neck with 0.2 ml of recombinants vFP115 or vFP116. This corresponded to a dose of approximately 4.0 $\log_{10}$ $TCID_{50}$. A group of 19 birds were left as uninoculated controls. At fourteen days post vaccination, chickens were bled and serum neutralizing titers in the sera were determined. Birds were challenged at 14 days by intra-ocular inoculation of 0.03

ml of the virulent heterologous serotype I IBDV challenge strain (designated STC) supplied by the USDA National Veterinary Services Laboratory. Five days after challenge, each chicken was necropsied and the bursa examined for gross lesions and the appearance of atrophy. The results are shown in Table 1.

The results indicate that inoculation of one dose of vFP115 expressing the VP2 structural protein leads to the induction of serum neutralizing antibody and 75% protection of challenged birds. Inoculation of vFP116 leads to the induction of a poor neutralizing antibody response but 50% of challenged birds are protected.

TABLE 1. Protective Efficacy of TROVAC-IBDV Recombinants in Chickens

Recombinant	#Protected/ Challenged[b]	% Protection	SN Titer[a]
vFP115	15/20	75	131
vFP116	10/19	53	6
Controls	0/19	0	0

a: Serum neutralization titer

b: Birds are considered protected in the absence of bursal atrophy and lesions.

Example 6 - IBDV RECOMBINANT POXVIRUS VACCINES

Recombinant poxviruses containing, in a nonessential region thereof, DNA from IBDV provide advantages as vaccines for inducing an immunological response in a host animal. Infectious bursal disease virus is very stable and persists in the environment for long periods. For economic reasons, poultry houses are rarely cleaned between broods and thus chickens are exposed to the virus early in life. Since elimination of virus by hygienic means is not possible, vaccination strategies need to be formed. Active immunization of

chickens is difficult in the presence of maternal antibody. In addition, since maternal antibody levels are variable and the rate of loss of antibody unpredictable, timing of vaccination is a problem. A successful vaccine will need to be able to boost immunity in the presence of maternal antibody and should also contain cross-reactive antigens from a number of different serotypes. In addition, an effective vaccine should not induce signs of disease in vaccinated birds.

TROVAC-IBDV recombinant vFP115 expressed the major structural protein VP2 which has been shown to contain at least one highly immunogenic region. The protein expressed by the TROVAC recombinant is recognizable by IBDV immune serum. Inoculation of this recombinant into susceptible birds resulted in 75% protection from bursal damage. Recombinant vFP116 contains the coding sequence for the polyprotein VP2, VP3, VP4. A protein probably corresponding to VPX, the VP2 precursor, was expressed which is also recognized by IBDV immune sera. Inoculation of this recombinant into susceptible birds lead to the development of low neutralizing antibody levels, but induced 53% protection from bursal damage.

The results indicate the potential of TROVAC-IBDV recombinants for vaccination against IBDV in the poultry industry. The restricted host range of FPV provides an inherent safety barrier to transmission of recombinant to non-vaccinated species. Use of antigenic regions of IBDV rather than whole virus eliminates the need to introduce live virus to the environment and may lessen the immunological pressure on the virus which leads to the emergence of variant strains. The large size of the FPV genome allows incorporation of multiple antigenic sequences and should allow for vaccination against a variety of strains.

Example 7 - FURTHER IMMUNOGENICITY AND EFFICACY STUDIES WITH vFP115

Effect of dose of inoculation on protective efficacy induced by vFP115. Groups of day old SPF chickens were inoculated with vFP115 by the subcutaneous route in the nape of the neck. The virus was administered in doses of 4.9, 5.5 or 6.2 $\log_{10}$ EID_{50} per bird. At 21 days post-vaccination, ten vaccinates and ten naive birds were bled and the sera analyzed for the presence of IBDV specific serum neutralizing (SN) antibody. At 28 days, birds were challenged by administration by the ocular route of 1.3 $\log_{10}$ EID_{50} of the heterologous Standard Challenge Strain of IBDV. At 5 days post-challenge, 5 birds from each group were necropsied and bursae examined for gross lesions. At 11 days post-challenge, the remaining birds were killed and bursa to body weight ratios determined. The results of analysis are shown in Table 2. The results indicate that increasing the inoculation dose has led to the induction of slightly higher levels of SN antibody, but that the protective efficacy is not enhanced. Birds were considered protected when the bursa to body weight ratio after challenge was greater than one standard deviation of the mean bursa to body weight ratio of infected control birds. Using this criteria, and considering bursa to body weight ratios of individual birds, protection ratios of 65%, 74% and 64% were obtained for vFP115 dosages of 4.9, 5.5 and 6.2 $\log_{10}$ EID_{50} respectively.

TABLE 2. Dose Response Study of Inoculation of vFP115 in Day Old Chickens

Dose	SN GMT[a]	Bursal Lesions[b] Positive/Total	Bursa/Body Weight Ratio[c]
4.9	13	1/5	3.5
5.5	35	2/5	3.2
6.2	102	1/5	3.2
Control	0	5/5	1.6

a: Geometric Mean Titer of sera of 10 birds
b: Bursa of 5 birds examined for gross lesions
c: Ratio expressed as a mean of 23 birds

Effect of Age of Bird on Protective Efficacy of vFP115. Groups of 30 one-, four-, seven- and fourteen day old SPF birds were inoculated by the subcutaneous route with 4.0 $\log_{10}$ EID_{50} of vFP115. At 21 days post-vaccination, 10 vaccinates and 5 naive controls of each group were bled and sera analyzed for the presence of SN antibody. At 28 days post-vaccination, all vaccinates and naive controls were challenged by the ocular route with 1.3 $\log_{10}$ EID_{50} of the heterologous STC virus strain. Four days post-challenge, birds were sacrificed and bursa examined for evidence of bursal damage. The results of analysis are shown in Table 3. The results indicate that while IBD specific SN titers and protection after challenge are obtained at one day of age, when vaccination is delayed past 4 days of age higher SN titers are obtained and the level of protection is increased.

TABLE 3. Effect of Age of Bird on Protective Efficacy of VFP115

Age Group	Treatment	GMT	Protection Ratio	% Protection
1 day	Vaccinates	126	23/30	77
	Controls		0/10	0
4 days	Vaccinates	666	25/30	83
	Controls		0/10	0
7 days	Vaccinates	1946	29/30	97
	Controls		1/10	0
14 days	Vaccinates	1408	30/30	100
	Controls		0/10	0

Effect of route of inoculation on induction of a protective immune response by vFP115. Groups of twenty 14 day old SPF birds were inoculated by (a) the intramuscular route in the leg, (b) ocular route or (c) oral route with 4.0 $\log_{10}$ $TCID_{50}$ of vFP115. At 14 and 28 days post-inoculation sera were collected and analyzed for the presence of IBDV specific SN antibody. At both 14 and 28 days post-vaccination, groups of birds were challenged by ocular inoculation of 2.5 $\log_{10}$ EID_{50} of the homologous Faragher strain of IBDV. Deaths were recorded and at 4 days post-challenge all birds were sacrificed and Bursa examined for the presence of macroscopic lesions. Significant neutralizing antibody responses were found only after inoculation of vFP115 by the intramuscular route with SN titers of approximately 2.0 $\log_{10}$ at 14 and 28 days post-inoculation. By ocular and oral routes, low SN titers were achieved in 30 and 10% of chickens, respectively. The results of challenge are shown in Table 4. All birds inoculated with vFP115 by the intramuscular route were fully protected from challenge which was pathogenic in all control non-vaccinated birds at 14 and 28 days post-inoculation. No

protection was observed following the oral route of inoculation. Partial protection was seen by the ocular route.

TABLE 4. Effect of Route of Inoculation on Protective Efficacy Induced By vFP115

Route of Inoculation	% Protection from challenge at 14 days post-vacc	28 days post-vacc
Intramuscular	100	100
Ocular	50	10
Oral	0	0

Example 8 - DEVELOPMENT OF A TROVAC RECOMBINANT EXPRESSING THE VP3 STRUCTURAL PROTEIN

Example 2 describes the development of a TROVAC based recombinant vFP116 expressing the VP2, VP4, VP3 polyprotein. Efficacy studies described in Example 5 indicate that this recombinant induces lower levels of protection than vFP115 expressing the VP2 protein after inoculation into susceptible chickens. *In vitro* studies showed that the VP2 protein expressed in the vFP116 construct is slightly larger than that expressed in the vFP115 construct and that expression of the VP3 protein is not detectable by a polyclonal serum. Immunofluorescence and immunoprecipitation analysis with a VP3 specific monoclonal antibody, however, indicated that the VP3 protein is expressed in vFP116. In order to evaluate the role of the VP3 protein in eliciting cross-protective immunity, a single recombinant was developed expressing the VP3 protein from the Faragher strain of IBDV.

Construction of a Fowlpox Insertion Plasmid at the F16 Locus. The plasmid pFP23K (described by Tartaglia et al., 1990) contains a 10.5 kb HindIII fragment from the fowlpox (FP) genome. A 7.3 kb NaeI\NdeI FP fragment was isolated from pFP23K and

ligated to a similarly cut pUC9 vector to generate pRW866. A unique FspI site within this FP fragment lies between two ORFs (intergenic region) and is the F16 insertion locus.

In order to create a multiple cloning site (MCS) cassette for the F16 locus, two PCR fragments were amplified from pFP23K using primers RW264 (SEQ ID NO:13) plus RW265 (SEQ ID NO:14) and RW266 (SEQ ID NO:15) plus RW267 (SEQ ID NO:16). The resulting fragments were mixed together and amplified with primers RW266 and RW267 which resulted in a single, fused fragment. This fragment was digested with EcoRI and NdeI and ligated into similarly cut pRW715 (derived from pUC9 by digesting with PvuII and ligating an EcoRI linker between the two PvuII sites), to yield pRW864. The MCS cassette consists of a polycloning region (SmaI-BamHI-HindIII sites) flanked on either side by translational stop codons in all six reading frames and a NotI site. A vaccinia early transcriptional stop signal is located on the HindIII end.

RW264: AATTAACCCGGGATCCAAGCTTCTAGCTAGCTAATTTTT
ATAGCGGCCGCTATAATCGTTAACTTATTAG

RW265: CTAGCTAGAAGCTTGGATCCCGGGTTAATTAATTAATAAAAA
GCGGCCGCGTTAAAGTAGAAAAATG

RW266: GTTACATATGTACAGAATCTGATCATAG

RW267: GCTAGAATTCTCTTAGTTTTTATAGTTG

The following describes a series of plasmid constructs which ultimately leads to the MCS cassette from pRW864 being inserted into the FspI site of pRW866 to generate the F16 insertion plasmid (pRW873). A cassette containing the *E. coli* lacZ gene coupled to the vaccinia 11K promoter was excised from pAM1BG as a BamHI/PstI fragment. Plasmid pAM1BG contains the lacZ BamHI fragment from pMC1871 (Casadaban et al., 1983) inserted in the previously described BamHI site 3′ of the 11K vaccinia virus promoter (Paoletti et al., 1984). The ends were repaired using Klenow polymerase and the cassette ligated into pRW864 cut with SmaI to yield

pRW867A. The lacZ gene cassette was excised from pRW867A using NotI and the ends repaired with Klenow polymerase. This fragment was then ligated into the unique FspI site in the FP sequences of pRW866 resulting in pRW868. The lacZ gene from pRW868 was excised using NotI and replaced with the MCS cassette derived as a NotI fragment from pRW864 resulting in pRW873, the F16 insertion plasmid.

Development of an FP recombinant expressing VP3. The complete IBDV VP3 ORF was excised from pCEN111 (described in Example 3) as a 1262 bp BamHI and Asp718 fragment and ligated into a similarly cut pSD554VC (a vaccinia donor plasmid containing the H6 promoter) to yield pFT1. A 112 bp PCR fragment was amplified from pCEN111 using oligonucleotides JP003 (SEQ ID NO:17) and JP004 (SEQ ID NO:18), digested with NruI/ScaI, and gel purified. This fragment was ligated into pFT1 digested completely with NruI and partially with ScaI to yield pIBDV-VP3II. This plasmid contains the vaccinia H6 promoter coupled to the VP3 ORF.

A PCR fragment was amplified from pRW823 which contains vaccinia virus H6 promoter sequences using oligonucleotides RG662 (SEQ ID NO:19) and RG663 (SEQ ID NO:20). This fragment was digested with HindIII/SmaI and ligated into the F16 insertion plasmid (pRW873) cut with the same enzymes resulting in pF16VQH6. A cassette containing part of the H6 promoter fused to the VP3 ORF was excised from pIBDV-VP3II with NruI/Asp718, the ends repaired with Klenow polymerase, and the purified fragment ligated into pF16VQH6 cut with NruI/SmaI to generate the donor plasmid pF16VP3F.

JP003 5′-AAGGTAGTACTGGCGTCC-3′

JP004 5′-TTATCGCGATATCCGTTAAGTTTGTATCGTAATATGTTCCCTCACA-ATCCACGA-3′

RG662 5′-TAAAAGCTTTTAATTAATTAGTCATC-3′

RG663 5′-TAACCCGGGCGATACAAACTTAACGG-3′

Plasmid pF16VP3F was used in *in vitro* recombination with TROVAC as the rescuing virus to derive

recombinant vFP186. Immunoprecipitation analysis using a VP3 specific monoclonal antibody has confirmed the expression of a protein of approximately 32 kd in CEF cells infected with the recombinant.

Example 9 - DEVELOPMENT OF TROVAC BASED RECOMBINANTS WITH ALTERED MODES OF EXPRESSION OF THE VP2 PROTEIN

It has been postulated that a protein displayed on the infected cell surface may lead to a more efficient induction of neutralizing antibody than if the protein is secreted or expressed internally. Previous studies have indicated that expression of a foreign antigen on the infected cell surface by a recombinant vaccinia virus, can be achieved by recombinant DNA techniques by adding appropriate signal and anchor sequences (Langford et al., 1986; Vijaya et al., 1988). The VP2 protein in IBDV infected cells is not a membrane bound glycoprotein and possesses neither an endogenous signal nor anchor sequences. A strategy was devised to add the appropriate signal and anchor sequences from the Newcastle Disease Virus fusion protein. The fusion protein is an integral membrane bound glycoprotein. This strategy is described below.

The IBDV VP2 ORF plus translational stop codon was excised from pCEN112 (described in Example 1) as an XbaI/SalI fragment and the ends repaired using Klenow polymerase. This cassette was ligated into the HincII site of pUC18 to generate pCE147. The vaccinia H6 promoter coupled to the NDV fusion gene signal sequence was obtained by isolating a HindIII/PstI fragment from pCE64 (for complete NDV Fusion sequences see Taylor et al., 1990). This fragment contains the H6 promoter fused to the first 25 codons from the N-terminus of the NDV fusion ORF. This fragment was ligated into pCE147 cut with HindIII/PstI to yield pCEN150.

In order to couple the last codon from the NDV fusion signal sequence with the first codon from the VP2

ORF, a PCR fragment was amplified from pCEN150 using oligonucleotides CE329 (SEQ ID NO:21) and CE330 (SEQ ID NO:22) as primers. The fragment was digested with KpnI/RsrII and ligated into pCEN150 cut with the same enzymes to generate pCEN156. The H6 promoted-NDV fusion signal sequence-VP2 ORF cassette was excised from pCEN156 with HindIII/EcoRI, the ends repaired using Klenow polymerase, and the cassette ligated into pCEN100 (the F8 insertion plasmid) cut with HpaI to generate the donor plasmid pIBDV-VP2-SS.

CE329 5′-GATCCCGGTACCTCTAATGCTGATCATCCGAACCGCGCTGACACTG-
AGCTGTACAAACCTGCAAGATCAAAC-3′

CE330 5′-GGACGCCGGTCCGGTTGTTGGCATC-3′

To add the NDV fusion transmembrane sequences to the above plasmid, a 240 bp PCR fragment was amplified from pIBDV-VP2-SS using primers RG583 (SEQ ID NO:23) and RG590 (SEQ ID NO:24). This fragment contains 49 codons plus stop codon from the C-terminus of the NDV fusion ORF (see Taylor et al., 1990). The purified fragment was digested with ScaI/BamHI and ligated into pIBDV-VP2-SS cut completely with BamHI and partially with ScaI to generate the donor plasmid pIBDV-VP2-SSA.

RG583 5′-GTGAGTACTTCATGGAGGTGGCCGACCTCAACTCTCCCCTGAAGA-
TTGCAGGAGCATTTGGCTTCAAAGACATAATCCGGGCTATAAGGA-
GGATCGTTTTAACTGTCATATC-3′

RG590 5′-TTAGGATCCTCATATTTTTGTAGTGGCTCTC-3′

In vitro recombination using plasmid pIBDV-VP2-SS and TROVAC as the rescuing virus generated recombinant vFP147. Expression analysis of this recombinant with both polyclonal immune serum and a VP2 specific monoclonal antibody indicated that the VP2 protein is expressed internally, and in addition is secreted into the tissue culture fluid. This result is in keeping with the addition of a signal sequence to the coding sequence of the VP2 protein. *In vitro* recombination using plasmid pIBDV-VP2-SSA and TROVAC as the rescuing virus generated recombinant vFP151. Expression analysis using both

polyclonal immune serum and the VP2 specific monoclonal antibody indicated that the VP2 protein is expressed at the infected cell surface as expected following the addition of an anchor sequence. The fact that the VP2 protein is still recognized by the monoclonal antibody in this form of presentation indicates that conformation of this particular epitope has not been altered by the manipulations.

Efficacy studies were performed by inoculating day-old SPF chickens with 4.0 $\log_{10}$ $TCID_{50}$ of each recombinant. At 28 days birds were challenged by ocular inoculation of the heterologous STC challenge strain. In contrast to previous results obtained with the unmodified VP2 expressed in vFP115, no protection was obtained after vaccination with either vFP147 or vFP151. Further *in vitro* studies using tunicamycin, an inhibitor of N-linked glycosylation, have indicated that the modified VP2 proteins expressed by both vFP147 and vFP151 are glycosylated whereas the unmodified VP2 expressed in vFP115 is not. It is postulated that the addition of sugar moieties to the VP2 protein may alter conformation of the protein in areas apart from the neutralizing epitope. Alternatively, the addition of the signal and anchor sequences as constructed here, may alter conformation of the protein. In either case it appears that the antibody induced by the modified constructions is not able to neutralize the heterologous challenge virus (STC). However, vFP147 and vFP151 and products therefrom are nonetheless useful. The modified VP2 expressed by these recombinants can be used as precursors to generate the VP2 protein; for example, by removal of the additional sugar moieties or to isolate secreted VP2 protein from tissue culture supernatant for further purification.

Example 10 - DEVELOPMENT OF POXVIRUS RECOMBINANTS EXPRESSING THE VP2 PROTEIN FROM HETEROLOGOUS STRAINS OF IBDV

IBDV strains show considerable variation in their ability to cross-neutralize. Sequence analysis of different strains has shown that one critical region involved in virus neutralization resides within a conformational epitope located on VP2. Sequence information for VP2 is available for the Faragher (Bayliss et al., 1990) and STC (Kibenge et al., 1990) strains and it has been determined that five amino acid differences between the two strains occur within the conformational epitope. A strategy was therefore devised to alter the coding sequence of the Faragher strain conformational epitope to conform with the sequence of the STC strain. This procedure is described below.

Mutagenesis of VP2 Faragher to VP2 STC. In order to change the VP2 Faragher sequence in pCEN120 (described in Example 1) to the VP2 STC sequence, five codons were changed in the VP2 ORF using PCR site directed mutagenesis (see Kibenge et al., 1990 for STC sequence). Oligonucleotide primers RG677 (SEQ ID NO:25) plus RG678 (SEQ ID NO:26) and RG685 (SEQ ID NO:27) plus RG686P (SEQ ID NO:28) were used to amplify a 530 bp and a 270 bp fragment respectively from pCEN100 (described in Example 3). The gel purified 270 bp fragment was further amplified using oligonucleotides RG702 (SEQ ID NO:29) and RG704 (SEQ ID NO:30). The 530 bp fragment was digested with SacI and partially digested with PstI. The 270 bp fragment was digested with SacI and NcoI. These purified PCR amplified fragments, which contain the five STC codon changes, were ligated into pCEN120 cut with PstI and NcoI. The resulting plasmid, pVP2-STC was confirmed by DNA sequencing analysis.

RG677 5′-TACACACTGCAGAGCAATGGGAACCTCAAGTTCGATCAGATG-3′

RG678 5′-GAAACACGAGCTCTCCCCCAACGCTGAGGCTTGTGATAG-3′

RG685 5′-GGAAGAGCTCGTGTTTCAAACAAGCGTCCAAGGCCTTGTACTGGG-
CGCCACCATCTACTTTATAGGCTTTGATGGGACTACGGTAATCAC-
CAGAGCTGTAGCCGCAGATAATGGGCTGACGGCCGGCACCGACAA-
TCTTATGCCATTCAATCTTG-3′

RG686P 5′-CCACCATGGATCGTCACTGCTAGGCTCCCACTTGCCGACCATGAC-
ATCTGATCCCCTGCCTGACCACCACTTTTGGAGGTCACTACCTCC-
AGTTTGATGGATGTGATTGGCTGGGTTATCTCATTGGTTGGAATG-
ACAAGATTGAATGGCATAAG-3′

RG702 5′-GGGAGAGCTCGTGTTTCAAACAAGCG-3′

RG704 5′-CCACCATGGATCGTCACTGC-3′

Construction of the new F8 insertion plasmid.

In order to remove all of F8 coding sequences from the original F8 insertion plasmid (pCEN100), a new F8 insertion plasmid was constructed. pJCA021 contains a 4900 bp PvuII/HincII fragment from TROVAC which includes the F8 gene and flanking sequences. A 4.2 kb NciI/PpuMI fragment was isolated from this plasmid and the ends repaired with Klenow polymerase. This fragment was ligated into pBluescript SK+ cut with XbaI/Asp718 and repaired with Klenow polymerase to yield pIY.

The strategy to delete the F8 ORF from pIY and replace it with a multiple cloning site (MCS) used PCR amplification of two fragments from pJCA021 with oligonucleotide primers containing the multiple cloning sequences. A 335 bp fragment was amplified from pJCA021 using oligonucleotides RG714 (SEQ ID NO:31) and RG715 (SEQ ID NO:32) and digested with HindIII and EcoRI. Similarly, a 465 bp fragment was amplified from pJCA021 using oligonucleotides RG716 (SEQ ID NO:33) and RG717 (SEQ ID NO:34) and digested with HindIII and BglII. The two PCR fragments were ligated into pIY cut with EcoRI and BglII in a three fragment ligation resulting in pF8. This plasmid is the new F8 insertion plasmid which contains a MCS consisting of SmaI, NruI, HindIII, BamHI and XhoI sites flanked by vaccinia early transcriptional stop signals and translational stops in all six frames. The length of the left arm is about 1430 bp and the length of the right arm is about 1380 bp. The F8 gene ORF which initiates at nucleotide position 495 and terminates at nucleotide position 1887 (Figure 2) is completely deleted.

RG714 5′-AACATATTTCCGAACAG-3′

RG715 5′-TCCAAGCTTTCGCGACCCGGGTTTTTATTAGCTAATTAGCAATAT-AGATTCAATATG-3′

RG716 5′-ATCAAGCTTGGATCCCTCGAGTTTTTATTGACTAGTTAATCATAA-GATAAATAATATACAGC-3′

RG717 5′-GATATAGAAGATACCAG-3′

Construction of donor plasmids and recombinants expressing VP2 STC. A cassette containing the H6 promoted VP2 (STC) ORF was excised as a 1.5 kb SmaI-Asp718 fragment from pVP2-STC. The ends were repaired using Klenow polymerase and ligated into pF8 cut with SmaI to generate the pF8-STC donor plasmid.

Plasmid pF8-STC was used in *in vitro* recombination with TROVAC as the rescuing virus to generate recombinant vFP209. Expression analysis of the recombinants using a polyclonal IBDV serum from chicken indicated that the VP2 protein is expressed internally in CEF cells infected by the recombinant.

SEQUENCE LISTING

(1) GENERAL INFORMATION:

(i) APPLICANT: Virogenetics Corporation

(ii) TITLE OF INVENTION: Infectious Bursal Disease Virus Recombinant Poxvirus Vaccine

(iii) NUMBER OF SEQUENCES: 34

(iv) CORRESPONDENCE ADDRESS:
(A) ADDRESSEE: Curtis, Morris & Safford c\o William S. Frommer
(B) STREET: 530 Fifth Avenue
(C) CITY: New York
(D) STATE: New York
(E) COUNTRY: USA
(F) ZIP: 10036

(v) COMPUTER READABLE FORM:
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(A) NAME: Frommer, William S.
(B) REGISTRATION NUMBER: 25,506
(C) REFERENCE/DOCKET NUMBER: 454310-2441

(ix) TELECOMMUNICATION INFORMATION:
(A) TELEPHONE: (212) 840-3333
(B) TELEFAX: (212) 840-0712

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 100 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

ACTTCATGGA GGTGGCCGAC CTCAACTCTC CCCTGAAGAT TGCAGGAGCA TTTGGCTTCA 60

AAGACATAAT CCGGGCTATA AGGAGGTGAG TCGACGGTAC 100

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 96 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

CGTCGACTCA CCTCCTTATA GCCCGGATTA TGTCTTTGAA GCCAAATGCT CCTGCAATCT 60

TCAGGGGAGA GTTGAGGTCG GCCACCTCCA TGAAGT 96

(2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 77 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

CGATATCATG ACAAACCTGC AAGATCAAAC CCAACAGATT GTTCCGTTCA TACGGAGCCT 60

TCTGATGCCA ACAACCG 77

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 80 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

GTCCGGTTGT TGGCATCAGA AGGCTCCGTA TGAACGGAAC AATCTGTTGG GTTTGATCTT 60

GCAGGTTTGT CATGATATCG 80

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 23 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

GACCTTGAGT GAGTCGACGG TAC 23

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 16 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

CGTCGACTCA CTCAAG 16

(2) INFORMATION FOR SEQ ID NO:7:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 3661 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

GATATCTGTG GTCTATATAT ACTACACCCT ACCGATATTA ACCAACGAGT TTCTCACAAG 60

AAAACTTGTT TAGTAGATAG AGATTCTTTG ATTGTGTTTA AAAGAAGTAC CAGTAAAAAG 120

TGTGGCATAT GCATAGAAGA AATAAACAAA AAACATATTT CCGAACAGTA TTTTGGAATT 180

CTCCCAAGTT GTAAACATAT TTTTTGCCTA TCATGTATAA GACGTTGGGC AGATACTACC 240

AGAAATACAG ATACTGAAAA TACGTGTCCT GAATGTAGAA TAGTTTTTCC TTTCATAATA 300

CCCAGTAGGT ATTGGATAGA TAATAAATAT GATAAAAAAA TATTATATAA TAGATATAAG 360

AAAATGATTT TTACAAAAAT AACCTATAAG AACAATAAAA ATATAATTAC ATTTACGGAA 420

AATAGCTGGT TTTAGTTTAC CAACTTAGAG TAATTATCAT ATTGAATCTA TATTGTTTTT 480

TAGTTATATA AAAACATGAT TAGCCCCCAA TCGGATGAAA ATATAAAAGA TGTTGAGAAT 540

TTCGAATACA ACAAAAAGAG GAATCGTACG TTGTCCATAT CCAAACATAT AAATAAAAAT 600

TCAAAAGTAG TATTATACTG GATGTTTAGA GATCAACGTG TACAAGATAA TTGGGCTTTA 660

ATTTACGCAC AACGATTAGC GTTAAAACTC AAAATACCTC TAAGAATATG CTTTTGTGTC 720

GTGCCAAAAT TTCACACTAC TACTTCTAGT ACACTTTATG TTTTTAATAT CCGGTCTTAA 780

AGAAGTCGCG GAAGAATGTA AAAGACTATG TATAGGGTTT TCATTGATAT ATGGCGTACC 840

AAAAGTAATA ATTCCGTGTA TAGTAAAAAA ATACAGAGTC GGAGTAATCA TAACGGATTT 900

CTTTCCATTA CGTGTTCCCG AAAGATTAAT GAAACAGACT GTAATATCTC TTCCAGATAA 960

CATACCTTTT ATACAAGTAG ACGCTCATAA TATAGTACCT TGTTGGGAAG CTTCTGATAA 1020

AGAAGAATAC GGTGCACGAA CTTTAAGAAA AAAGATATTT GATAAATTAT ATGAATATAT 1080

GACAGAATTT CCTGTTGTTC GTAAACATCC ATACGGTCCA TTTTCTATAT CTATTGCAAA 1140

ACCCAAAAAT ATATCATTAG ACAAGACGGT ATTACCCGTA AAATGGGCAA CGCCTGGAAC 1200

AAAAGCTGGA ATAATTGTTT TAAAAGAATT TATAAAAAAC AGATTACCGT CATACGACGC 1260

GGATCATAAC AATCCTACGT GTGACGCTTT GAGTAACTTA TCTCCGTGGC TACATTTTGG 1320

TCATGTATCC GCACAACGTG TTGCCTTAGA AGTATTAAAA TGTATACGAG AAAGCAAAAA 1380

AAACGTTGAA ACGTTTATAG ATGAAATAAT TGTAAGAAGA GAACTATCGG ATAATTTTTG 1440

TTACTATAAC AAACATTATG ATAGTATCCA GTCTACTCAT TCATGGGTTA GAAAAACATT 1500

AGAAGATCAC ATTAATGATC CTAGAAAGTA TATATATTCC ATTAAACAAC TCGAAAAAGC 1560

GGAAACTCAT GATCCTCTAT GGAACGCGTC ACAAATGCAG ATGGTGAGAG AAGGAAAAAT 1620

GCATAGTTTT TTACGAATGT ATTGGGCTAA GAAGATACTT GAATGGACTA GAACACCTGA 1680

AGACGCTTTG AGTTATAGTA TCTATTTGAA CAACAAGTAC GAACTAGACG GCACGGATCC 1740

TAACGGATAC GTAGGTTGTA TGTGGTCTAT TTGCGGATTA CACGATAGAG CGTGGAAAGC 1800

AAGACCGATA TTTGGAAAGA TAAGATATAT GAATTATGAG AGTTCTAAGA AGAAATTTGA 1860

TGTTGCTGTA TTTATACAGA AATACAATTA AGATAAATAA TATACAGCAT TGTAACCATC 1920

GTCATCCGTT ATACGGGGAA TAATATTACC ATACAGTATT ATTAAATTTT CTTACGAAGA 1980

ATATAGATCG GTATTTATCG TTAGTTTATT TTACATTTAT TAATTAAACA TGTCTACTAT 2040

TACCTGTTAT GGAAATGACA AATTTAGTTA TATAATTTAT GATAAAATTA AGATAATAAT 2100

AATGAAATCA AATAATTATG TAAATGCTAC TAGATTATGT GAATTACGAG GAAGAAAGTT 2160

TACGAACTGG AAAAAATTAA GTGAATCTAA AATATTAGTC GATAATGTAA AAAAAATAAA 2220

TGATAAAACT AACCAGTTAA AAACGGATAT GATTATATAC GTTAAGGATA TTGATCATAA 2280

AGGAAGAGAT ACTTGCGGTT ACTATGTACA CCAAGATCTG GTATCTTCTA TATCAAATTG 2340

GATATCTCCG TTATTCGCCG TTAAGGTAAA TAAAATTATT AACTATTATA TATGTAATGA 2400

ATATGATATA CGACTTAGCG AAATGGAATC TGATATGACA GAAGTAATAG ATGTAGTTGA 2460

TAAATTAGTA GGAGGATACA ATGATGAAAT AGCAGAAATA ATATATTTGT TTAATAAATT 2520

TATAGAAAAA TATATTGCTA ACATATCGTT ATCAACTGAA TTATCTAGTA TATTAAATAA 2580

TTTTATAAAT TTTATAAATT TTAATAAAAA ATACAATAAC GACATAAAGA TATTTAATCT 2640

TTAATTCTTG ATCTGAAAAA CACATCTATA AAACTAGATA AAAAGTTATT CGATAAAGAT 2700

AATAATGAAT CGAACGATGA AAAATTGGAA ACAGAAGTTG ATAAGCTAAT TTTTTTCATC 2760

TAAATAGTAT TATTTTATTG AAGTACGAAG TTTTACGTTA GATAAATAAT AAAGGTCGAT 2820

TTTTACTTTG TTAAATATCA AATATGTCAT TATCTGATAA AGATACAAAA ACACACGGTG 2880

ATTATCAACC ATCTAACGAA CAGATATTAC AAAAAATACG TCGGACTATG GAAAACGAAG 2940

CTGATAGCCT CAATAGAAGA AGCATTAAAG AAATTGTTGT AGATGTTATG AAGAATTGGG 3000

ATCATCCTCA ACGAAGAAAT AGATAAAGTT CTAAACTGGA AAAATGATAC ATTAAACGAT 3060

TTAGATCATC TAAATACAGA TGATAATATT AAGGAAATCA TACAATGTCT GATTAGAGAA 3120

TTTGCGTTTA AAAAGATCAA TTCTATTATG TATAGTTATG CTATGGTAAA ACTCAATTCA 3180

GATAACGAAC ATTGAAAGAT AAAATTAAGG ATTATTTTAT AGAAACTATT CTTAAAGACA 3240

AACGTGGTTA TAAACAAAAG CCATTACCCG GATTGGAAAC TAAAATACTA GATAGTATTA 3300

TAAGATTTTA AAAACATAAA ATTAATAGGT TTTTATAGAT TGACTTATTA TATACAATAT 3360

GGATAAAAGA TATATATCAA CTAGAAAGTT GAATGACGGA TTCTTAATTT TATATTATGA 3420

TTCAATAGAA ATTATTGTCA TGTCGTGTAA TCATTTTATA AATATATCAG CGTTACTAGC 3480

TAAGAAAAAC AAGGACTTTA ATGAATGGCT AAAGATAGAA TCATTTAGAG AAATAATAGA 3540

TACTTTAGAT AAAATTAATT ACGATCTAGG ACAACGATAT TGTGAAGAAC TTACGGCGCA 3600

TCACATTCCA GTGTAATTAT TGAGGTCAAA GCTAGTAACT TAATAGATGA CAGGACAGCT 3660

G 3661

(2) INFORMATION FOR SEQ ID NO:8:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 69 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

CTAGACACTT TATGTTTTTT AATATCCGGT CTTAAAAGCT TCCCGGGGGA TCCTTATACG 60

GGGAATAAT 69

(2) INFORMATION FOR SEQ ID NO:9:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 65 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

ATTATTCCCC GTATAAGGAT CCCCCGGGAA GCTTTTAAGA CCGGATATTA AAAAACATAA 60

AGTGT 65

(2) INFORMATION FOR SEQ ID NO:10:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 72 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

GATCAGAAAA ACTAGCTAGC TAGTACGTAG TTAACGTCGA CCTGCAGAAG CTTCTAGCTA 60

GCTAGTTTTT AT 72

(2) INFORMATION FOR SEQ ID NO:11:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 72 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

AGCTATAAAA ACTAGCTAGC TAGAAGCTTC TGCAGGTCGA CGTTAACTAC GTACTAGCTA 60

GCTAGTTTTT CT 72

(2) INFORMATION FOR SEQ ID NO:12:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 3659 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

GATATCTGTG GTCTATATAT ACTACACCCT ACCGATATTA ACCAACGAGT TTCTCACAAG 60

AAAACTTGTT TAGTAGATAG AGATTCTTTG ATTGTGTTTA AAAGAAGTAC CAGTAAAAAG 120

TGTGGCATAT GCATAGAAGA AATAAACAAA AAACATATTT CCGAACAGTA TTTTGGAATT 180

CTCCCAAGTT GTAAACATAT TTTTTGCCTA TCATGTATAA GACGTTGGGC AGATACTACC 240

AGAAATACAG ATACTGAAAA TACGTGTCCT GAATGTAGAA TAGTTTTTCC TTTCATAATA 300

CCCAGTAGGT ATTGGATAGA TAATAAATAT GATAAAAAAA TATTATATAA TAGATATAAG 360

AAAATGATTT TTACAAAAAT ACCTATAAGA ACAATAAAAA TATAATTACA TTTACGGAAA 420

ATAGCTGGTT TTAGTTTACC AACTTAGAGT AATTATCATA TTGAATCTAT ATTGTTTTTT 480

AGTTATATAA AAACATGATT AGCCCCCAAT CGGATGAAAA TATAAAAGAT GTTGAGAATT 540

TCGAATACAA CAAAAAGAGG AATCGTACGT TGTCCATATC CAAACATATA AATAAAAATT 600

CAAAAGTAGT ATTATACTGG ATGTTTAGAG ATCAACGTGT ACAAGATAAT TGGGCTTTAA 660

TTTACGCACA ACGATTAGCG TTAAAACTCA AAATACCTCT AAGAATATGC TTTTGTGTCG 720

TGCCAAAATT TCACACTACT ACTTCTAGAC ACTTTATGTT TTTAATATCC GGTCTTAAAG 780

AAGTCGCGGA AGAATGTAAA AGACTATGTA TAGGGTTTTC ATTGATATAT GGCGTACCAA 840

AAGTAATAAT TCCGTGTATA GTAAAAAAAT ACAGAGTCGG AGTAATCATA ACGGATTTCT 900

TTCCATTACG TGTTCCCGAA AGATTAATGA AACAGACTGT AATATCTCTT CCAGATAACA 960

TACCTTTTAT ACAAGTAGAC GCTCATAATA TAGTACCTTG TTGGGAAGCT TCTGATAAAG 1020

AAGAATACGG TGCACGAACT TTAAGAAAAA AGATATTTGA TAAATTATAT GAATATATGA 1080

CAGAATTTCC TGTTGTTCGT AAACATCCAT ACGGTCCATT TTCTATATCT ATTGCAAAAC 1140

CCAAAAATAT ATCATTAGAC AAGACGGTAT TACCCGTAAA ATGGGCAACG CCTGGAACAA 1200

AAGCTGGAAT AATTGTTTTA AAAGAATTTA TAAAAAACAG ATTACCGTCA TACGACGCGG 1260

ATCATAACAA TCCTACGTGT GACGCTTTGA GTAACTTATC TCCGTGGCTA CATTTTGGTC 1320

ATGTATCCGC ACAACGTGTT GCCTTAGAAG TATTAAAATG TATACGAGAA AGCAAAAAAA 1380

ACGTTGAAAC GTTTATAGAT GAAATAATTG TAAGAAGAGA ACTATCGGAT AATTTTTGTT 1440

ACTATAACAA ACATTATGAT AGTATCCAGT CTACTCATTC ATGGGTTAGA AAAACATTAG 1500

AAGATCACAT TAATGATCCT AGAAAGTATA TATATTCCAT TAAACAACTC GAAAAAGCGG 1560

AAACTCATGA TCCTCTATGG AACGCGTCAC AAATGCAGAT GGTGAGAGAA GGAAAAATGC 1620

ATAGTTTTTT ACGAATGTAT TGGGCTAAGA AGATACTTGA ATGGACTAGA ACACCTGAAG 1680

ACGCTTTGAG TTATAGTATC TATTTGAACA ACAAGTACGA ACTAGACGGC ACGGATCCTA 1740

ACGGATACGT AGGTTGTATG TGGTCTATTT GCGGATTACA CGATAGAGCG TGGAAAGCAA 1800

GACCGATATT TGGAAAGATA AGATATATGA ATTATGAGAG TTCTAAGAAG AAATTTGATG 1860

TTGCTGTATT TATACAGAAA TACAATTAAG ATAAATAATA TACAGCATTG TAACCATCGT 1920

CATCCGTTAT ACGGGGAATA ATATTACCAT ACAGTATTAT TAAATTTTCT TACGAAGAAT 1980

ATAGATCGGT ATTTATCGTT AGTTTATTTT ACATTTATTA ATTAAACATG TCTACTATTA 2040

CCTGTTATGG AAATGACAAA TTTAGTTATA TAATTTATGA TAAAATTAAG ATAATAATAA 2100

TGAAATCAAA TAATTATGTA AATGCTACTA GATTATGTGA ATTACGAGGA AGAAAGTTTA 2160

CGAACTGGAA AAAATTAAGT GAATCTAAAA TATTAGTCGA TAATGTAAAA AAAATAAATG 2220

ATAAAACTAA CCAGTTAAAA ACGGATATGA TTATATACGT TAAGGATATT GATCATAAAG 2280

GAAGAGATAC TTGCGGTTAC TATGTACACC AAGATCTGGT ATCTTCTATA TCAAATTGGA 2340

TATCTCCGTT ATTCGCCGTT AAGGTAAATA AAATTATTAA CTATTATATA TGTAATGAAT 2400

ATGATATACG ACTTAGCGAA ATGGAATCTG ATATGACAGA AGTAATAGAT GTAGTTGATA 2460

AATTAGTAGG AGGATACAAT GATGAAATAG CAGAAATAAT ATATTTGTTT AATAAATTTA 2520

TAGAAAAATA TATTGCTAAC ATATCGTTAT CAACTGAATT ATCTAGTATA TTAAATAATT 2580

TTATAAATTT TATAAATTTT AATAAAAAAT ACAATAACGA CATAAAGATA TTTAATCTTT 2640

AATTCTTGAT CTGAAAAACA CATCTATAAA ACTAGATAAA AAGTTATTCG ATAAAGATAA 2700

TAATGAATCG AACGATGAAA AATTGGAAAC AGAAGTTGAT AAGCTAATTT TTTTCATCTA 2760

AATAGTATTA TTTTATTGAA GTACGAAGTT TTACGTTAGA TAAATAATAA AGGTCGATTT 2820

TTACTTTGTT AAATATCAAA TATGTCATTA TCTGATAAAG ATACAAAAAC ACACGGTGAT 2880

TATCAACCAT CTAACGAACA GATATTACAA AAAATACGTC GGACTATGGA AAACGAAGCT 2940

GATAGCCTCA ATAGAAGAAG CATTAAAGAA ATTGTTGTAG ATGTTATGAA GAATTGGGAT 3000

CATCCTCAAC GAAGAAATAG ATAAAGTTCT AAACTGGAAA AATGATACAT TAAACGATTT 3060

AGATCATCTA AATACAGATG ATAATATTAA GGAAATCATA CAATGTCTGA TTAGAGAATT 3120

TGCGTTTAAA AAGATCAATT CTATTATGTA TAGTTATGCT ATGGTAAAAC TCAATTCAGA 3180

TAACGAACAT TGAAAGATAA AATTAAGGAT TATTTTATAG AAACTATTCT TAAAGACAAA 3240

CGTGGTTATA AACAAAAGCC ATTACCCGGA TTGGAAACTA AAATACTAGA TAGTATTATA 3300

AGATTTTAAA AACATAAAAT TAATAGGTTT TTATAGATTG ACTTATTATA TACAATATGG 3360

ATAAAAGATA TATATCAACT AGAAAGTTGA ATGACGGATT CTTAATTTTA TATTATGATT 3420

CAATAGAAAT TATTGTCATG TCGTGTAATC ATTTTATAAA TATATCAGCG TTACTAGCTA 3480

AGAAAAACAA GGACTTTAAT GAATGGCTAA AGATAGAATC ATTTAGAGAA ATAATAGATA 3540

CTTTAGATAA AATTAATTAC GATCTAGGAC AACGATATTG TGAAGAACTT ACGGCGCATC 3600

ACATTCCAGT GTAATTATTG AGGTCAAAGC TAGTAACTTA ATAGATGACA GGACAGCTG 3659

(2) INFORMATION FOR SEQ ID NO:13:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 70 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

AATTAACCCG GGATCCAAGC TTCTAGCTAG CTAATTTTTA TAGCGGCCGC TATAATCGTT 60

AACTTATTAG 70

(2) INFORMATION FOR SEQ ID NO:14:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 67 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

CTAGCTAGAA GCTTGGATCC CGGGTTAATT AATTAATAAA AAGCGGCCGC GTTAAAGTAG 60

AAAAATG 67

(2) INFORMATION FOR SEQ ID NO:15:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 28 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

GTTACATATG TACAGAATCT GATCATAG 28

(2) INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 28 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

GCTAGAATTC TCTTAGTTTT TATAGTTG 28

(2) INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 18 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

AAGGTAGTAC TGGCGTCC 18

(2) INFORMATION FOR SEQ ID NO:18:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 54 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:18:

TTATCGCGAT ATCCGTTAAG TTTGTATCGT AATATGTTCC CTCACAATCC ACGA 54

(2) INFORMATION FOR SEQ ID NO:19:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 26 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

TAAAAGCTTT TAATTAATTA GTCATC 26

(2) INFORMATION FOR SEQ ID NO:20:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 26 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

TAACCCGGGC GATACAAACT TAACGG 26

(2) INFORMATION FOR SEQ ID NO:21:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 72 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

GATCCCGGTA CCTCTAATGC TGATCATCCG AACCGCGCTG ACACTGAGCT GTACAAACCT 60

GCAAGATCAA AC 72

(2) INFORMATION FOR SEQ ID NO:22:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 25 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:

GGACGCCGGT CCGGTTGTTG GCATC 25

(2) INFORMATION FOR SEQ ID NO:23:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 112 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:

GTGAGTACTT CATGGAGGTG GCCGACCTCA ACTCTCCCCT GAAGATTGCA GGAGCATTTG 60

GCTTCAAAGA CATAATCCGG GCTATAAGGA GGATCGTTTT AACTGTCATA TC 112

(2) INFORMATION FOR SEQ ID NO:24:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 31 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:24:

TTAGGATCCT CATATTTTTG TAGTGGCTCT C 31

(2) INFORMATION FOR SEQ ID NO:25:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 42 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:25:

TACACACTGC AGAGCAATGG GAACCTCAAG TTCGATCAGA TG 42

(2) INFORMATION FOR SEQ ID NO:26:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 39 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:26:

GAAACACGAG CTCTCCCCCA ACGCTGAGGC TTGTGATAG 39

(2) INFORMATION FOR SEQ ID NO:27:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 155 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:27:

GGAAGAGCTC GTGTTTCAAA CAAGCGTCCA AGGCCTTGTA CTGGGCGCCA CCATCTACTT 60

TATAGGCTTT GATGGGACTA CGGTAATCAC CAGAGCTGTA GCCGCAGATA ATGGGCTGAC 120

GGCCGGCACC GACAATCTTA TGCCATTCAA TCTTG 155

(2) INFORMATION FOR SEQ ID NO:28:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 155 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:28:

CCACCATGGA TCGTCACTGC TAGGCTCCCA CTTGCCGACC ATGACATCTG ATCCCCTGCC 60

TGACCACCAC TTTTGGAGGT CACTACCTCC AGTTTGATGG ATGTGATTGG CTGGGTTATC 120

TCATTGGTTG GAATGACAAG ATTGAATGGC ATAAG 155

(2) INFORMATION FOR SEQ ID NO:29:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 26 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:29:

GGGAGAGCTC GTGTTTCAAA CAAGCG 26

(2) INFORMATION FOR SEQ ID NO:30:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 20 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:30:

CCACCATGGA TCGTCACTGC 20

(2) INFORMATION FOR SEQ ID NO:31:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 17 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:31:

AACATATTTC CGAACAG 17

(2) INFORMATION FOR SEQ ID NO:32:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 57 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:32:

TCCAAGCTTT CGCGACCCGG GTTTTTATTA GCTAATTAGC AATATAGATT CAATATG 57

(2) INFORMATION FOR SEQ ID NO:33:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 62 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:33:

ATCAAGCTTG GATCCCTCGA GTTTTTATTG ACTAGTTAAT CATAAGATAA ATAATATACA 60

GC 62

(2) INFORMATION FOR SEQ ID NO:34:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 17 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:34:

GATATAGAAG ATACCAG 17

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WHAT IS CLAIMED IS:

1. A recombinant poxvirus containing therein DNA from infectious bursal disease virus in a nonessential region of the poxvirus genome.

2. A recombinant poxvirus as in claim 1 wherein said DNA codes for and expresses an infectious bursal disease virus structural protein.

2. A recombinant poxvirus as in claim 2 wherein said structural protein is VP2.

3. A recombinant poxvirus as in claim 2 wherein said structural protein is VP3.

4. A recombinant poxvirus as in claim 2 wherein said structural protein is polyprotein VP2, VP3, VP4.

5. A recombinant poxvirus as in claim 1 wherein the poxvirus is an avipox virus.

6. A recombinant avipox virus as in claim 6 wherein the avipox virus is fowlpox virus.

7. A recombinant fowlpox virus as in claim 7 which is selected from the group consisting of vFP115, vFP116, vFP147, vFP151, vFP186 and vFP209.

8. A vaccine for inducing an immunological response in a host animal inoculated with said vaccine, said vaccine comprising a carrier and a recombinant poxvirus containing, in a nonessential region thereof, DNA from infectious bursal disease virus.

9. A vaccine as in claim 9 wherein said DNA codes for and expresses an infectious bursal disease virus structural protein.

10. A vaccine as in claim 10 wherein said structural protein is VP2.

11. A vaccine as in claim 10 wherein said structural protein is VP3.

12. A vaccine as in claim 10 wherein said structural protein is polyprotein VP2, VP3, VP4.

13. A vaccine as in claim 9 wherein the poxvirus is an avipox virus.

14. A vaccine as in claim 14 wherein the avipox virus is fowlpox virus.

15. A vaccine as in claim 14 wherein the host animal is a chicken.

AMENDED CLAIMS

[received by the International Bureau on 14 December 1992 (14.12.92);
second claim 2 renumbered as claim 3,
original claims 3-15 renumbered as claims 4-16;
claim 1 unchanged (2 pages)]

1. A recombinant poxvirus containing therein DNA from infectious bursal disease virus in a nonessential region of the poxvirus genome.

2. A recombination poxvirus as in claim 1 wherein said DNA codes for and expresses an infectious bursal disease virus structural protein.

3. A recombinant poxvirus as in claim 2 wherein said structural protein is VP2.

4. A recombinant poxvirus as in claim 2 wherein said structural protein is VP3.

5. A recombinant poxvirus as in claim 2 wherein said structural protein is polyprotein VP2, VP3, VP4.

6. A recombinant poxvirus as in claim 1 wherein the poxvirus is an avipox virus.

7. A recombinant avipox virus as in claim 6 wherein the avipox virus is fowlpox virus.

8. A recombinant fowlpox virus as in claim 7 which is selected from the group consisting of vFP115, vFP116, vFP147, vFP151, vFP186 and vFP209.

9. A vaccine for inducing an immunological response in a host animal inoculated with said vaccine, said vaccine comprising a carrier and a recombinant poxvirus containing, in a nonessential region thereof, DNA from infectious bursal disease virus.

10. A vaccine as in claim 9 wherein said DNA codes for and expresses an infectious bursal disease virus structural protein.

11. A vaccine as in claim 10 wherein said structural protein is VP2.

12. A vaccine as in claim 10 wherein said structural protein is VP3.

13. A vaccine as in claim 10 wherein said structural protein is polyprotein VP2, VP3, VP4.

14. A vaccine as in claim 9 wherein the

15. A vaccine as in claim 14 wherein the avipox virus is fowlpox virus.

16. A vaccine as in claim 14 wherein the host animal is a chicken.

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        10         20         30         40         50         60         70         80         90        100
GATATCTGTGGTCTATATATACTACACCCTACCGATATTAACCAACGAGTTTCTCACAAGAAAACTTGTTTAGTAGATAGAGATTCTTTGATTGTGTTTA
       110        120        130        140        150        160        170        180        190        200
AAAGAAGTACCAGTAAAAAGTGTGGCATATGCATAGAAGAAATAAACAAAAAACATATTTCCGAACAGTATTTTGGAATTCTCCCAAGTTGTAAACATAT
       210        220        230        240        250        260        270        280        290        300
TTTTTGCCTATCATGTATAAGACGTTGGGCAGATACTACCAGAAATACAGATACTGAAAATACGTGTCCTGAATGTAGAATAGTTTTTCCTTTCATAATA
       310        320        330        340        350        360        370        380        390        400
CCCAGTAGGTATTGGATAGATAATAAATATGATAAAAAAATATTATATAATAGATATAAGAAAATGATTTTTACAAAAATAACCTATAAGAACAATAAAA
       410        420        430        440        450        460        470        480        490        500
ATATAATTACATTTACGGAAAATAGCTGGTTTTAGTTTACCAACTTAGAGTAATTATCATATTGAATCTATATTGTTTTTTAGTTATATAAAAACATGAT
       510        520        530        540        550        560        570        580        590        600
TAGCCCCCAATCGGATGAAAATATAAAAGATGTTGAGAATTTCGAATACAACAAAAAGAGGAATCGTACGTTGTCCATATCCAAACATATAAATAAAAAT
       610        620        630        640        650        660        670        680        690        700
TCAAAAGTAGTATTATACTGGATGTTTAGAGATCAACGTGTACAAGATAATTGGGCTTTAATTTACGCACAACGATTAGCGTTAAAACTCAAAATACCTC
       710        720        730        740        750        760        770        780        790        800
TAAGAATATGCTTTTGTGTCGTGCCAAAATTTCACACTACTACTTCTAGACACTTTATGTTTTTTTAATATCCGGTCTTAAAGAAGTCGCGGAAGAATGTA
       810        820        830        840        850        860        870        880        890        900
AAAGACTATGTATAGGGTTTTCATTGATATATGGCGTACCAAAAGTAATAATTCCGTGTATAGTAAAAAAATACAGAGTCGGAGTAATCATAACGGATTT
       910        920        930        940        950        960        970        980        990       1000
CTTTCCATTACGTGTTCCCGAAAGATTAATGAAACAGACTGTAATATCTCTTCCAGATAACATACCTTTTATACAAGTAGACGCTCATAATATAGTACCT
      1010       1020       1030       1040       1050       1060       1070       1080       1090       1100
TGTTGGGAAGCTTCTGATAAAGAAGAATACGGTGCACGAACTTTAAGAAAAAAGATATTTGATAAATTATATGAATATATGACAGAATTTCCTGTTGTTC
      1110       1120       1130       1140       1150       1160       1170       1180       1190       1200
GTAAACATCCATACGGTCCATTTTCTATATCTATTGCAAAACCCAAAAATATATCATTAGACAAGACGGTATTACCCGTAAAATGGGCAACGCCTGGAAC
      1210       1220       1230       1240       1250       1260       1270       1280       1290       1300
AAAAGCTGGAATAATTGTTTTAAAAGAATTTATAAAAAACAGATTACCGTCATACGACGCGGATCATAACAATCCTACGTGTGACGCTTTGAGTAACTTA
```

FIG. 1A

1310 1320 1330 1340 1350 1360 1370 1380 1390 1400
TCTCCGTGGCTACATTTTGGTCATGTATCCGCACAACGTGTTGCCTTAGAAGTATTAAAATGTATACGAGAAAGCAAAAAAAACGTTGAAACGTTTATAG

1410 1420 1430 1440 1450 1460 1470 1480 1490 1500
ATGAAATAATTGTAAGAAGAGAACTATCGGATAATTTTTGTTACTATAACAAACATTATGATAGTATCCAGTCTACTCATTCATGGGTTAGAAAAACATT

1510 1520 1530 1540 1550 1560 1570 1580 1590 1600
AGAAGATCACATTAATGATCCTAGAAAGTATATATATTCCATTAAACAACTCGAAAAAGCGGAAACTCATGATCCTCTATGGAACGCGTCACAAATGCAG

1610 1620 1630 1640 1650 1660 1670 1680 1690 1700
ATGGTGAGAGAAGGAAAAATGCATAGTTTTTTACGAATGTATTGGGCTAAGAAGATACTTGAATGGACTAGAACACCTGAAGACGCTTTGAGTTATAGTA

1710 1720 1730 1740 1750 1760 1770 1780 1790 1800
TCTATTTGAACAACAAGTACGAACTAGACGGCACGGATCCTAACGGATACGTAGGTTGTATGTGGTCTATTTGCGGATTACACGATAGAGCGTGGAAAGC

1810 1820 1830 1840 1850 1860 1870 1880 1890 1900
AAGACCGATATTTGGAAAGATAAGATATATGAATTATGAGAGTTCTAAGAAGAAATTTGATGTTGCTGTATTTATACAGAAATACAATTAAGATAAATAA

1910 1920 1930 1940 1950 1960 1970 1980 1990 2000
TATACAGCATTGTAACCATCGTCATCCGTTATACGGGGAATAATATTACCATACAGTATTATTAAATTTTCTTACGAAGAATATAGATCGGTATTTATCG

2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
TTAGTTTATTTTACATTTATTAATTAAACATGTCTACTATTACCTGTTATGGAAATGACAAATTTAGTTATATAATTTATGATAAAATTAAGATAATAAT

2110 2120 2130 2140 2150 2160 2170 2180 2190 2200
AATGAAATCAAATAATTATGTAAATGCTACTAGATTATGTGAATTACGAGGAAGAAAGTTTACGAACTGGAAAAAATTAAGTGAATCTAAAATATTAGTC

2210 2220 2230 2240 2250 2260 2270 2280 2290 2300
GATAATGTAAAAAAAATAAATGATAAAACTAACCAGTTAAAAACGGATATGATTATATACGTTAAGGATATTGATCATAAAGGAAGAGATACTTGCGGTT

2310 2320 2330 2340 2350 2360 2370 2380 2390 2400
ACTATGTACACCAAGATCTGGTATCTTCTATATCAAATTGGATATCTCCGTTATTCGCCGTTAAGGTAAATAAAATTATTAACTATTATATATGTAATGA

2410 2420 2430 2440 2450 2460 2470 2480 2490 2500
ATATGATATACGACTTAGCGAAATGGAATCTGATATGACAGAAGTAATAGATGTAGTTGATAAATTAGTAGGAGGATACAATGATGAAATAGCAGAAATA

FIG. 1B

2510 2520 2530 2540 2550 2560 2570 2580 2590 2600
ATATATTTGTTTAATAAATTTATAGAAAAATATATTGCTAACATATCGTTATCAACTGAATTATCTAGTATATTAAATAATTTTATAAATTTTATAAATT

2610 2620 2630 2640 2650 2660 2670 2680 2690 2700
TTAATAAAAAATACAATAACGACATAAAGATATTTAATCTTTAATTCTTGATCTGAAAAACACATCTATAAAACTAGATAAAAAGTTATTCGATAAAGAT

2710 2720 2730 2740 2750 2760 2770 2780 2790 2800
AATAATGAATCGAACGATGAAAAATTGGAAACAGAAGTTGATAAGCTAATTTTTTTCATCTAAATAGTATTATTTTATTGAAGTACGAAGTTTTACGTTA

2810 2820 2830 2840 2850 2860 2870 2880 2890 2900
GATAAATAATAAAGGTCGATTTTTACTTTGTTAAATATCAAATATGTCATTATCTGATAAAGATACAAAAACACACGGTGATTATCAACCATCTAACGAA

2910 2920 2930 2940 2950 2960 2970 2980 2990 3000
CAGATATTACAAAAAATACGTCGGACTATGGAAAACGAAGCTGATAGCCTCAATAGAAGAAGCATTAAAGAAATTGTTGTAGATGTTATGAAGAATTGGG

3010 3020 3030 3040 3050 3060 3070 3080 3090 3100
ATCATCCTCAACGAAGAAATAGATAAAGTTCTAAACTGGAAAAATGATACATTAAACGATTTAGATCATCTAAATACAGATGATAATATTAAGGAAATCA

3110 3120 3130 3140 3150 3160 3170 3180 3190 3200
TACAATGTCTGATTAGAGAATTTGCGTTTAAAAAGATCAATTCTATTATGTATAGTTATGCTATGGTAAAACTCAATTCAGATAACGAACATTGAAAGAT

3210 3220 3230 3240 3250 3260 3270 3280 3290 3300
AAAATTAAGGATTATTTTATAGAAACTATTCTTAAAGACAAACGTGGTTATAAACAAAAGCCATTACCCGGATTGGAAACTAAAATACTAGATAGTATTA

3310 3320 3330 3340 3350 3360 3370 3380 3390 3400
TAAGATTTTAAAAACATAAAATTAATAGGTTTTTATAGATTGACTTATTATATACAATATGGATAAAAGATATATATCAACTAGAAAGTTGAATGACGGA

3410 3420 3430 3440 3450 3460 3470 3480 3490 3500
TTCTTAATTTTATATTATGATTCAATAGAAATTATTGTCATGTCGTGTAATCATTTTATAAATATATCAGCGTTACTAGCTAAGAAAAACAAGGACTTTA

3510 3520 3530 3540 3550 3560 3570 3580 3590 3600
ATGAATGGCTAAAGATAGAATCATTTAGAGAAATAATAGATACTTTAGATAAAATTAATTACGATCTAGGACAACGATATTGTGAAGAACTTACGGCGCA

3610 3620 3630 3640 3650 3660
TCACATTCCAGTGTAATTATTGAGGTCAAAGCTAGTAACTTAATAGATGACAGGACAGCTG

FIG. 1C

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   1 GATATCTGTG GTCTATATAT ACTACACCCT ACCGATATTA ACCAACGAGT TTCTCACAAG
  61 AAAACTTGTT TAGTAGATAG AGATTCTTTG ATTGTGTTTA AAAGAAGTAC CAGTAAAAAG
 121 TGTGGCATAT GCATAGAAGA AATAAACAAA AAACATATTT CCGAACAGTA TTTTGGAATT
 181 CTCCCAAGTT GTAAACATAT TTTTTGCCTA TCATGTATAA GACGTTGGGC AGATACTACC
 241 AGAAATACAG ATACTGAAAA TACGTGTCCT GAATGTAGAA TAGTTTTTCC TTTCATAATA
 301 CCCAGTAGGT ATTGGATAGA TAATAAATAT GATAAAAAAA TATTATATAA TAGATATAAG
 361 AAAATGATTT TTACAAAAAT ACCTATAAGA ACAATAAAAA TATAATTACA TTTACGGAAA
 421 ATAGCTGGTT TTAGTTTACC AACTTAGAGT AATTATCATA TTGAATCTAT ATTGTTTTTT
 481 AGTTATATAA AAACATGATT AGCCCCCAAT CGGATGAAAA TATAAAAGAT GTTGAGAATT
 541 TCGAATACAA CAAAAAGAGG AATCGTACGT TGTCCATATC CAAACATATA AATAAAAATT
 601 CAAAAGTAGT ATTATACTGG ATGTTTAGAG ATCAACGTGT ACAAGATAAT TGGGCTTTAA
 661 TTTACGCACA ACGATTAGCG TTAAAACTCA AAATACCTCT AAGAATATGC TTTTGTGTCG
 721 TGCCAAAATT TCACACTACT ACTTCTAGAC ACTTTATGTT TTTAATATCC GGTCTTAAAG
 781 AAGTCGCGGA AGAATGTAAA AGACTATGTA TAGGGTTTTC ATTGATATAT GGCGTACCAA
 841 AAGTAATAAT TCCGTGTATA GTAAAAAAAT ACAGAGTCGG AGTAATCATA ACGGATTTCT
 901 TTCCATTACG TGTTCCCGAA AGATTAATGA AACAGACTGT AATATCTCTT CCAGATAACA
 961 TACCTTTTAT ACAAGTAGAC GCTCATAATA TAGTACCTTG TTGGGAAGCT TCTGATAAAG
1021 AAGAATACGG TGCACGAACT TTAAGAAAAA AGATATTTGA TAAATTATAT GAATATATGA
1081 CAGAATTTCC TGTTGTTCGT AAACATCCAT ACGGTCCATT TTCTATATCT ATTGCAAAAC
1141 CCAAAAATAT ATCATTAGAC AAGACGGTAT TACCCGTAAA ATGGGCAACG CCTGGAACAA
1201 AAGCTGGAAT AATTGTTTTA AAAGAATTTA TAAAAAACAG ATTACCGTCA TACGACGCGG
1261 ATCATAACAA TCCTACGTGT GACGCTTTGA GTAACTTATC TCCGTGGCTA CATTTTGGTC
1321 ATGTATCCGC ACAACGTGTT GCCTTAGAAG TATTAAAATG TATACGAGAA AGCAAAAAAA
1381 ACGTTGAAAC GTTTATAGAT GAAATAATTG TAAGAAGAGA ACTATCGGAT AATTTTTGTT
1441 ACTATAACAA ACATTATGAT AGTATCCAGT CTACTCATTC ATGGGTTAGA AAAACATTAG
1501 AAGATCACAT TAATGATCCT AGAAAGTATA TATATTCCAT TAAACAACTC GAAAAAGCGG
1561 AAACTCATGA TCCTCTATGG AACGCGTCAC AAATGCAGAT GGTGAGAGAA GGAAAAATGC
1621 ATAGTTTTTT ACGAATGTAT TGGGCTAAGA AGATACTTGA ATGGACTAGA ACACCTGAAG
1681 ACGCTTTGAG TTATAGTATC TATTTGAACA ACAAGTACGA ACTAGACGGC ACGGATCCTA
1741 ACGGATACGT AGGTTGTATG TGGTCTATTT GCGGATTACA CGATAGAGCG TGGAAAGCAA
1801 GACCGATATT TGGAAAGATA AGATATATGA ATTATGAGAG TTCTAAGAAG AAATTTGATG
1861 TTGCTGTATT TATACAGAAA TACAATTAAG ATAAATAATA TACAGCATTG TAACCATCGT
1921 CATCCGTTAT ACGGGGAATA ATATTACCAT ACAGTATTAT TAAATTTTCT TACGAAGAAT
1981 ATAGATCGGT ATTTATCGTT AGTTTATTTT ACATTTATTA ATTAAACATG TCTACTATTA
2041 CCTGTTATGG AAATGACAAA TTTAGTTATA TAATTTATGA TAAAATTAAG ATAATAATAA
2101 TGAAATCAAA TAATTATGTA AATGCTACTA GATTATGTGA ATTACGAGGA AGAAAGTTTA
2161 CGAACTGGAA AAAATTAAGT GAATCTAAAA TATTAGTCGA TAATGTAAAA AAAATAAATG
2221 ATAAAACTAA CCAGTTAAAA ACGGATATGA TTATATACGT TAAGGATATT GATCATAAAG
2281 GAAGAGATAC TTGCGGTTAC TATGTACACC AAGATCTGGT ATCTTCTATA TCAAATTGGA
2341 TATCTCCGTT ATTCGCCGTT AAGGTAAATA AAATTATTAA CTATTATATA TGTAATGAAT
2401 ATGATATACG ACTTAGCGAA ATGGAATCTG ATATGACAGA AGTAATAGAT GTAGTTGATA
2461 AATTAGTAGG AGGATACAAT GATGAAATAG CAGAAATAAT ATATTTGTTT AATAAATTTA
2521 TAGAAAAATA TATTGCTAAC ATATCGTTAT CAACTGAATT ATCTAGTATA TTAAATAATT
2581 TTATAAATTT TATAAATTTT AATAAAAAAT ACAATAACGA CATAAAGATA TTTAATCTTT
2641 AATTCTTGAT CTGAAAAACA CATCTATAAA ACTAGATAAA AAGTTATTCG ATAAAGATAA
2701 TAATGAATCG AACGATGAAA AATTGGAAAC AGAAGTTGAT AAGCTAATTT TTTTCATCTA
2761 AATAGTATTA TTTTATTGAA GTACGAAGTT TTACGTTAGA TAAATAATAA AGGTCGATTT
2821 TTACTTTGTT AAATATCAAA TATGTCATTA TCTGATAAAG ATACAAAAAC ACACGGTGAT
2881 TATCAACCAT CTAACGAACA GATATTACAA AAAATACGTC GGACTATGGA AAACGAAGCT
2941 GATAGCCTCA ATAGAAGAAG CATTAAAGAA ATTGTTGTAG ATGTTATGAA GAATTGGGAT
3001 CATCCTCAAC GAAGAAATAG ATAAAGTTCT AAACTGGAAA AATGATACAT TAAACGATTT
3061 AGATCATCTA AATACAGATG ATAATATTAA GGAAATCATA CAATGTCTGA TTAGAGAATT
3121 TGCGTTTAAA AAGATCAATT CTATTATGTA TAGTTATGCT ATGGTAAAAC TCAATTCAGA
3181 TAACGAACAT TGAAAGATAA AATTAAGGAT TATTTTATAG AAACTATTCT TAAAGACAAA
3241 CGTGGTTATA AACAAAAGCC ATTACCCGGA TTGGAAACTA AAATACTAGA TAGTATTATA
3301 AGATTTTAAA AACATAAAAT TAATAGGTTT TTATAGATTG ACTTATTATA TACAATATGG
3361 ATAAAAGATA TATATCAACT AGAAAGTTGA ATGACGGATT CTTAATTTTA TATTATGATT
3421 CAATAGAAAT TATTGTCATG TCGTGTAATC ATTTTATAAA TATATCAGCG TTACTAGCTA
3481 AGAAAAACAA GGACTTTAAT GAATGGCTAA AGATAGAATC ATTTAGAGAA ATAATAGATA
3541 CTTTAGATAA AATTAATTAC GATCTAGGAC AACGATATTG TGAAGAACTT ACGGCGCATC
3601 ACATTCCAGT GTAATTATTG AGGTCAAAGC TAGTAACTTA ATAGATGACA GGACAGCTG
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FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/06100

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :C12N 7/00; C12P 21/02; A61K 39/12
US CL :435/69.3, 235.1; 424/89

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 435/69.3, 235.1; 424/89

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

none

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS ONLINE, search terms: poxvirus, infectious bursal disease virus, VP2, VP3, VP4

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Azad et al. "Vaccines 90", published 1990 by Cold Spring Harbor Laboratory Press, CSH (NY), "Full Protection Against an Immunodepressive Viral Disease by a Recombinant Antigen Produced in Yeast", pages 59-62, entire document.	1, 2, 5, 6, 8
X,P	Archives of Virology, Volume 120, issued November 1991, C.D. Bayliss et al., "A Recombinant Fowlpox Virus that Expresses the VP2 Antigen of Infectious Bursal Disease Virus Induces Protection Against Mortality Caused by the Virus", pages 193-205, entire document.	1, 2, 5, 6, 8
Y	Virology, volume 161, issued October 1987, A.A. Azad et al., "Deletion Mapping and Expression in Escherichia coli of the Large Genomic Segment of a Birnavirus", pages 145-152, entire document.	1, 2, 5, 6, 8
Y	Nucleic Acids Research, Volume 14, No. 12, issued September 1986, P.J. Hudson et al., "Genomic Structure of the Large RNA Segment of Infectious Bursal Disease Virus", pages 5001-5012, entire document.	1, 2, 5, 6, 8

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

09 OCTOBER 1992

Date of mailing of the international search report

22 OCT 1992

Name and mailing address of the ISA/
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. NOT APPLICABLE

Authorized officer

JOAN ELLIS

Telephone No. (703) 308-0196

International application No.
PCT/US92/06100

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Journal of General Virology, Volume 69, issued November 1988, F.S.B. Kibenge et al., "Biochemistry and Immunology of Infectious Bursal Disease Virus", pages 1757-1775, see especially page 1769.	1, 2, 5, 6, 8
Y	Journal of Virology, Volume 64, No. 4, issued April 1990, J. Taylor et al., "Newcastle disease Viurs Fusion Protein Expressed in a Fowlpox Virus Recombinant Confers Protection in Chickens", pages 1441-1450, entire document.	1, 2, 5, 6, 8
Y	Vaccine, Volume 6, issued December 1988, J. Taylor et al. "Protective Immunity Against Avian Influenza Induced by a Fowlpox Virus Recombinant", pages 504-508, entire document.	1, 2, 5, 6, 8

International application No.
PCT/US92/06100

BOX I. OBSERVATIONS WHERE CLAIMS WERE FOUND UNSEARCHABLE

2. Where no meaningful search could be carried out, specifically:

Two claims were labelled as claim 2, therefore, it was unclear what applicants intended by the second claim 2. In addition, it was not clear on which claim 2 claims 3 and 4 depended. Claims 7, 9, 10, and 14 all were dependent upon themselves. Accordingly, neither they, or the claims dependent upon them, were searchable.